Musa Pest Fact Sheet No. 1

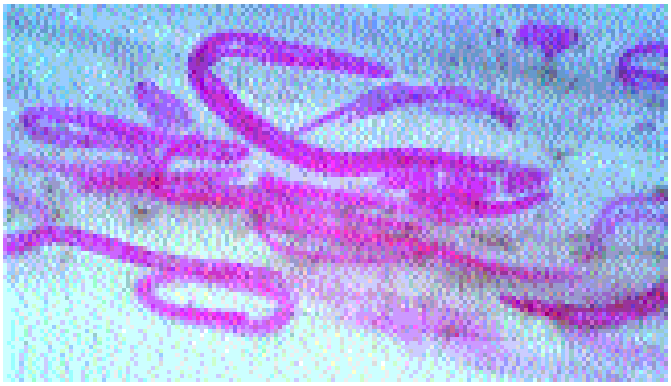
THE BURROWING NEMATODE OF BANANAS, *RADOPHOLUS SIMILIS* COBB, 1913

J.L. Sarah, J. Pinochet and J. Stanton (December 1996)

Burrowing nematode *(Radopholus similis*) is one of the most important root pathogens attacking bananas in the intertropical zone of production. Vegetative propagation using infested corms or suckers has disseminated this pest throughout the world. Although a number of nematode species infect bananas and plantains, *R. similis* is considered to be the main nematode problem of intensive commercial bananas, especially Cavendish types, oriented towards export markets. It is also common on plantain and cooking bananas cultivated in the lowlands of central and eastern Africa, and the Caribbean (Puerto Rico). It is however, generally absent in plantain roots in west Africa and central America. The burrowing nematode is also absent in the highlands of central-eastern Africa and in the subtropical zones of production where a more temperate climate prevails (mediterranean area, Canary islands, Madeira, Cape Province, Taiwan), although it may be present under greenhouse cultivation. The distribution of this nematode species is mainly due to its preference for a temperature-range fluctuating between 24 and 32°C. Optimum reproduction occurs at around 30°C. It does not reproduce below 16-17°C or above 33°C.

Radopholus similis is a migratory endoparasitic nematode which completes its life-cycle in 20-25 days in the root and corm tissues (Figure 1). Juveniles and adult females are active mobile forms which may leave the roots in case of adverse conditions. Migratory stages in the soil can easily invade new roots. This species has a pronounced sexual dimorphism in which males present an atrophied stylet and are considered to be non-parasitic. Nematode penetration occurs by preference near the root apex, but *R. similis* can invade any portion of the root length. As the nematode migrates inter and intracellularly, it feeds on the cytoplasm of cortex cells, collapsing cell walls, and causing cavities and tunnels which evolve as a necrosis and may extend to the whole cortex. The stele is not damaged by *R. similis* although it can penetrate young stelar tissues.

Necrosis of root and corm tissues (Figures 2 and 3) is accelerated by other pathogens such as fungi and bacteria, among which, *Cylindrocarpon musae*, *Acremonium stromaticum*, and *Fusarium* spp. are common. Fungi of the genera *Cylindrocladium* have been found to be pathogenic in the French West Indies causing lesions similar to those of *R. similis*; the association of these two parasites causes severe damage. The destruction of root and corm tissues reduces water and mineral uptake which results in a reduction of plant growth and development. This leads to severe losses in bunch weight and increases significantly the time period between two successive harvests. Furthermore, this destruction also results in a tendency for plants to uproot or topple (Figure 4), particularly during strong winds and heavy rain periods, with a high economic impact. Crop losses caused by *R. similis* depend, in great measure, on soil fertility. Under extreme conditions where soils are poor and eroded, cumulative losses due to bunch weight reduction and uprooting may reach 75% in three cycles of production. Such heavy losses are exceptional but have been recorded at one site in Côte d'Ivoire. However, in the peat soils of that country or in the volcanic soils of Cameroon, cumulative crop losses are generally below 30 %. In Central America (Costa Rica and Panama) and South America (Colombia and Ecuador), crop losses due to uprooting only, fluctuate between 12 and 18%, whereas in the Sula valley in Honduras they tend to be lower (around 5%). Damage depends also on the pathogenicity of the nematode population which varies greatly between production zones. Pathogenicity of populations appears to be linked to their reproductive fitness in plant tissues. Some African populations are more pathogenic than populations from the West Indies, Sri Lanka or Queensland (Australia). In the Caribbean-Central America zone, three pathotypes have been characterized, based on their relative pathogenicity, reproduction rate, host preference (ABB-banana types, plantains or others) and caryotype. A pathotype from Puerto Rico is a more severe pathogen on plantains than on other bananas and has 5 chromosome pairs, in contrast to the central American types that prevail on Cavendish bananas, which possess only 4 chromosome pairs. More recently, African populations of *R. similis* have been found to have both 4 and 5 chromosome pairs, although the latter is less common. Enzymatic (PGI) and DNA (RAPD) analyses have revealed two genomic groups which are not related to pathogenicity. The distribution of these genomic groups all over the world appears to be linked to historical contingencies of planting material spread.



1. R. similis ***in banana root tissue, showing all stages of life-cycle (eggs, juveniles, females) Acid fuschic stain. (Photo M. Boisseau).***

2. *Root necrosis which may extend on all cortex but stele is free (Photo J.L. Sarah).*

Reducing nematode populations in the soil before planting and the use of cleansed or nematode-free planting material are of primary importance in the control of *R. similis*. Nematode populations may be reduced to an undetectable level by a one-year fallow with non-host plants, such as *Chromolaena odorata* (Asteracea) which is very effective in Africa. Six-seven weeks of complete flooding can be as effective as 10-12 months of fallow in reducing nematode populations.

International Network for the Improvement of Banana and Plantain, Parc Scientifique Agropolis II,
34397 Montpellier Cedex 5, FRANCE - Tel: 33 (0)4 67 61 13 02, Fax: 33 (0)4 67 61 03 34, e-mail: inibap@cgnet.com

3. *Corm necrosis (black head disease) (Photo J.L. Sarah).*

However, this method is often not practicable as flooding requires the land to be levelled and a permanent water supply. Although soil fumigation is quite effective in controlling nematodes, few fumigants are still authorized today and application costs may be prohibitive. Moreover, these chemicals are broad spectrum biocides with a detrimental effect on soil organisms.

Nematodes may be introduced into clean soil through infested planting material and, ideally, planting material should be produced in nematode-free soils. Lightly infested corms or suckers may be treated to remove nematodes. The simplest method consists of paring the corms superficially to remove lesioned tissue. However, nematodes located deep within the cortex in non-necrosed tissues may escape removal. Sun exposure of pared material for 2 weeks may further reduce the nematode population, but such techniques cannot be applied to small suckers which are quite fragile and need to be replanted rapidly. Paring followed by hot water treatments (52-55°C for 15-20 minutes) has been a common and effective practice in Central America and Australia. However, hot water treatments are labour intensive and require careful monitoring (temperature and timing of exposure is critical) to be efficient and to limit the negative effects on the plants. Planting material disinfestation using chemicals can also be achieved by dipping plant material in a nematicide solution (2 500 ppm) for 30 minutes. The technique known as "pralinage" is a significant improvement over dipping. This involves the use of a nematicidal mud mixture which permits instantaneous coating of the plant. It is recommended to use either bentonite (15 kg in 100 l of water + 400-500 g of active ingredient) or a natural clay (proportion of clay to be mixed with water must be adapted).

The best way to avoid recontamination of nematode-free soil is to use nematode-free plants propagated through *in vitro* techniques. This is now one of the most common sources of planting material in many producing regions and should be the only method allowed for the introduction of banana plant material into virgin land.

Once introduced, eradication of *R. similis* from the soil is virtually impossible and populations will build-up more or less rapidly after planting. Yield losses may be reduced through propping or guying of pseudostems to avoid toppling. Improved drainage is also an important factor in reducing nematode damage in high rainfall areas, such as parts of Central America. In the same way, any measure which improves fertility and root development may increase plant tolerance to nematodes. Such measures include soil preparation before planting, incorporation of organic matter in the soil, fertilization and irrigation.

Chemical control is currently the most common method of controlling nematode populations. Nematicides are generally non-volatile organophosphates or carbamates, which are applied as granules on the soil surface around the mat. Emulsifiable compounds are applied as liquid sprays or through irrigation systems (e.g. in Canary islands). The optimum application time, dose and frequency are determined by nematicide efficiency, environmental conditions, as well as pathogenicity of local nematode strains and population dynamics. In most production areas, nematicide applications vary between 2 to 3 g of active ingredient per mat and 2-3 applications per year. To avoid problems of enhanced biodegration induced by repetitive use of the same nematicide, alternation with different compounds is recommended. Although nematicides are generally effective in controlling nematodes and are easy to use, they are expensive, highly toxic and may have a negative impact on the environment.

Several research teams are now collaborating with the breeding programmes of FHIA in Honduras and CIRAD-FLHOR in Guadeloupe as well as with INIBAP in developing cultivar resistance. Pisang Jari Buaya (AA) diploid cultivar types have long been identified as a source of resistance to *R. similis*. This resistance has been incorporated into the parental lines used in the breeding of improved hybrids and is the source of resistance found in Goldfinger (FHIA-01). Recently, a source of resistance to *R. similis* has also been detected in several different genome groups, such as AAA - Yangambi Km 5 and some *acuminata* and *balbisiana* wild and cultivated diploids. A method for the early screening of germplasm has been developed. This allows the rapid elimination of the most susceptible genotypes from the screening programme. Only the most interesting germplasm is retained for subsequent field trials, thus reducing the size and expense of the final evaluation. It should be noted that the differences in pathogenicity among populations of *R. similis* will further complicate efforts in plant breeding and selection against this pest, especially in the ability to obtain broad resistance useful for all production areas. The best approach is to evaluate potentially resistant banana varieties against local pathogenic forms of the nematode in each ecological production zone through coherent regional research networks. Trials have already been established in Uganda and Nigeria (IITA), Cameroon (CRBP), Honduras (FHIA), Martinique and Guadeloupe (CIRAD-FLHOR) and Australia (QDPI).

Your help is needed. INIBAP is encouraging studies on genomic and pathogenic diversity of *R. similis* to improve integrated control strategies (e.g. crop rotation, fallow, resistance, chemical control) adapted to certain regions. This work will also help to determine the geographic origin of the burrowing nematode and, therefore, additional sources of resistance and possibly natural enemies. You can help by sending root samples infested with *R. similis* to Jean-Louis Sarah (Laboratoire de nématologie, CIRAD-FLHOR, B.P. 5035, 34032 Montpellier Cedex 01, France - e-mail: sarah@cirad.fr). Root samples must be shaken to remove excess soil but not washed, put into closed plastic bags and send by express mail. Details on collection date, location, cultivar and cultural practices must be included.

4. *Uprooting due to root destruction (Photo J. Pinochet).*